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NASA Headquarters  
Washington, D. C. 20546

From: H. C. Urey and Bartholomew Nagy

Re: Semi-Annual Report, NASA Grants NsG-541 and  
NGR-05-009-043

Research conducted during the period, May 1, 1966 to December 31, 1966 consisted of four basic aspects of investigations.

## NsG-541

1. The study of the high molecular weight, insoluble "polymer-type" matter in terrestrial sedimentary rocks (kerogen), coal and in the Orgueil carbonaceous meteorite continued. The basic ozonolysis procedure has been described in the last progress report, dated July 12, 1966. A number of benzene carboxylic, as well as pyridine carboxylic acids have been found together with adipic acid by ozonolysis of the insoluble fraction of the Orgueil meteorite. The similarity of these compounds to those obtained by the same oxidative degradation process from bituminous coal and kerogen is interesting. It should be noted that all samples were first extracted with solvents to remove soluble organic matter which could be, in part, contaminated with recent biological matter. Consequently, it is safe to assume that the "polymer-type" substance is indigenous to the samples and that it had not been affected by recent contaminations. Control experiments with granite (which contains no organic matter) showed that the ozonolysis procedure does not lead to the synthesis of organic chemical artifacts. Additional experiments are conducted, these involve ozonolysis of carbon black, an abiological "polymer-type" organic substance, in order to explore the possibility that the degradation products which were found in the samples of biological origin, i. e. in coal and kerogen, can also be obtained from abiological substances. Ozonolysis studies of a Precambrian kerogen ( $3.2 - 3.4 \times 10^9$  years old) is also in progress.

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2. Studies of the lipid and hydrocarbon composition of soils, marine sediments, sedimentary rocks and carbonaceous meteorites continued. To be able to better evaluate the results control experiments are performed on the lipid and hydrocarbon composition of recent plant (blue-green algae) and animal (beef liver) tissues. The analytical procedure involves solvent extraction, followed by saponification, elution and thin layer chromatography, infrared and ultraviolet spectroscopy, optical rotatory dispersion studies, molecular sieve fractionation and finally gas-liquid chromatography with tandem mass spectrometry. It was noted that there appears to be a systematic difference between the lipid composition of these five different types of samples. Current investigations are expected to better define the exact nature of these differences and, possibly, their origin.

3. Investigations of the carbonaceous meteorite microstructures (organized elements) was resumed. Petrographic thin sections and powdered preparations, (the latter included samples that were treated with 6N HCl and 48% HF), had been systematically studied. Emphasis was placed on round, flattened and opaque particles which were known from previous electron probe microanalyses to contain iron oxide (magnetite) and some Ni. Because of the mineral content, these particles are generally regarded to be indigenous to the meteorites. They also seem to have a thin coating or wall that may consist of organic matter. A micromanipulator technique was developed to collect a sufficient quantity of these particles for direct insertion and mild pyrolysis in the mass spectrometer in order to analyze their organic content, if such matter is indeed present. That the latter may be the case is indicated by the presence of a number of round, transparent particles in the acid treated samples; such particles were not observed in untreated preparations. Samples from the Orgueil, Ivuna and Murray carbonaceous meteorite are studied. Control samples include the Holbrook non-carbonaceous meteorite and Precambrian rocks.

NGR-05-009-043

4. A unique system consisting of a combined mass spectrometer and (both capillary and conventional packed column) gas chromatograph is developed and modified from commercially purchased equipment. Reaction gas chromatography is a part of the system. A micropyrolysis unit and hydrogenation oven for carbon skeleton analysis of polymer degradation products preceeds and is connected to the gas chromatograph inlet port. Consequently, the instrument will be able to analyze organic substances of very high molecular weights as well as compounds of the usual molecular weight ranges. Research on engineering problems arising from the different flow rates from the capillary columns than those originally designed for the Biemann separator in the mass spectrometer


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has been successful and the problems were solved. Sample splitting between the hydrogen flame detector and mass spectrometer inlet is coordinated with a pressure program regulator improved in this laboratory, to eliminate changes of flow rate caused by temperature programming. It was found upon calibrations with the known compounds, that the instrument with these modifications is more sensitive than the original, commercial specifications call for. Soon this system will be fully operational and it is expected to be probably the most versatile and accurate system for the lunar sample analyses. Analyses of rock organic matter will then begin, using this improved gas chromatographic-mass spectrometric system.

  
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Harold C. Urey

  
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Bartholomew Nagy